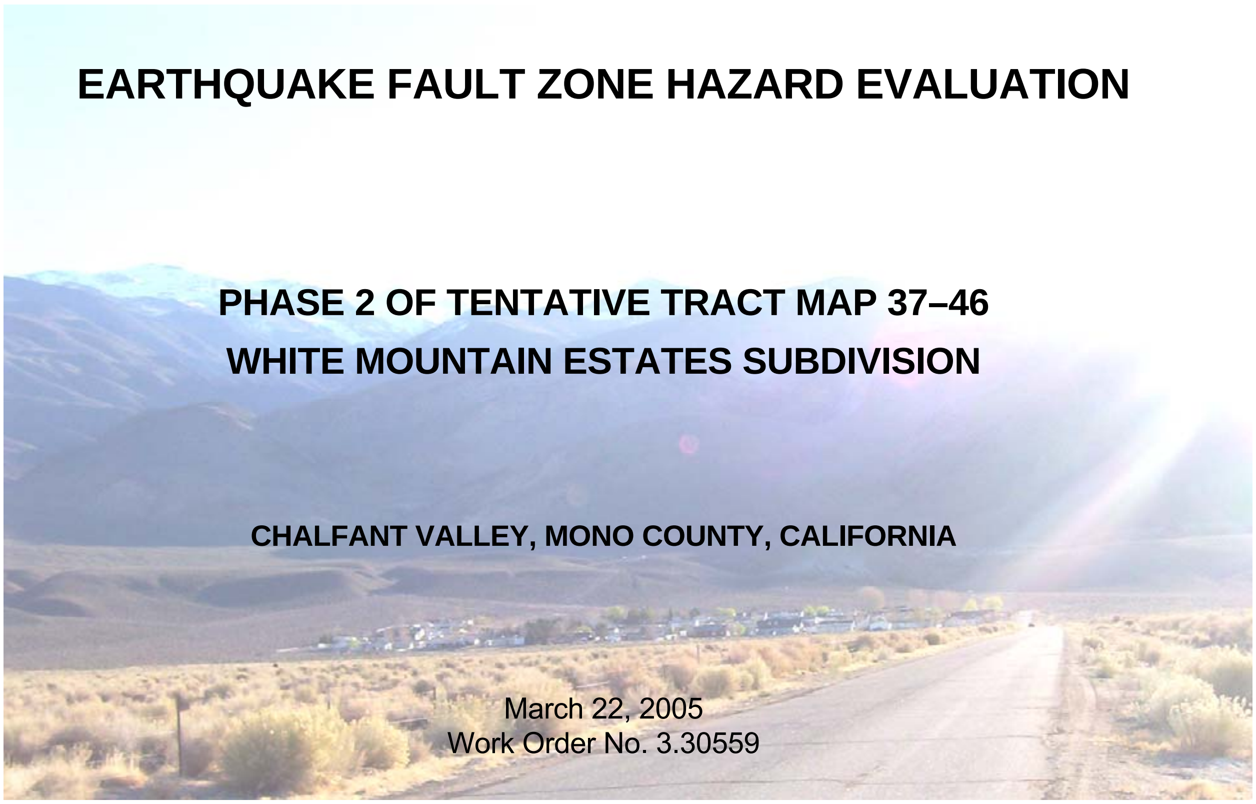

# EARTHQUAKE FAULT ZONE HAZARD EVALUATION

## PHASE 2 OF TENTATIVE TRACT MAP 37–46
## WHITE MOUNTAIN ESTATES SUBDIVISION

### CHALFANT VALLEY, MONO COUNTY, CALIFORNIA

March 22, 2005
Work Order No. 3.30559


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# 1.0. INTRODUCTION

This report presents the findings of Sierra Geotechnical Services, Inc. (SGSI) Alquist-Priolo Earthquake Fault Zone (APEFZ) hazard evaluation for the proposed White Mountain Estates Subdivision, located in the Chalfant Valley area, Mono County, California (Figure 1). Sierra Geotechnical Services Inc. was contracted by Mr. Robert Stark of Tumbleweed Manufactured Homes to perform the evaluation. Mr. Stark plans to subdivide Phase 2 of Tentative Tract 37-46 into a total of eleven parcels, eight of which are intended for residential use.

## 1.1. PURPOSE and SCOPE

Because the project site is located within an APEFZ (Figure 2), the purpose of this study was prepared in order to satisfy both the State and County requirements pursuant to the APEFZ Act (California Public Resources Code, Division 2, Chapter 7.5). The general scope of this report encompasses that which was presented in our Proposal and Cost Estimate dated July 14, 2004 and in our Request for Change Order Authorization Dated October 6, 2004. The scope of work for this study includes the following:

- Review of published and unpublished, readily available information regarding regional and local geology and hydrogeology;
- Review of similar fault-hazard studies and reports prepared for nearby properties;
- Review of readily available aerial photographs of the project site and surrounding vicinity for evidence of surface rupture or other significant fault-related geomorphic features;
- Performance of a limited reconnaissance of the project site and the area surrounding the site to a radius of at least 300 feet;
- Excavation of approximately 3,785 lineal feet of exploratory fault trenching extending across the entire site in a general east-to-west direction, which is perpendicular to the regional trend mapped faults and observed lineaments; and,
- Preparation of this report summarizing our findings and conclusions of the evaluation and our recommendations for the project.

## 1.2. USER RELIANCE

This APEFZ hazard evaluation was prepared solely for the benefit and reliance of White Mountain Estates, LLC (WME). Any use of, or reliance upon this information by a party other than WME shall be solely at the risk of such third party and without legal recourse against SGSI or their respective employees, officers, or owners, regardless of whether the action in which recovery of damages is sought based on contract, tort, (including the sole, concurrent, or other negligence and strict liability of SGSI), statute, or otherwise.

## 2.0. SITE DESCRIPTION

### 2.1. SITE LOCATION AND VICINITY CHARACTERISTICS

The subject site is located within Chalfant Valley, which is at the southern end of Mono County and at the eastern edge of California (Figure 1). Chalfant Valley is the southernmost valley that comprises the greater Northern Owens Valley. Hammil Valley and Benton Valley comprise the rest of Northern Owens Valley to the north, respectively. Chalfant Valley is bound on the east by the White Mountain range, and on the west by the Bishop Tuff Volcanic Tableland. Further to the west is the Sierra Nevada mountain range. The nearest incorporated population is approximately twelve miles to the south, being Bishop, in Inyo County, California. The community of Chalfant is located approximately two and one-half miles to the north, and approximately twenty-two miles further north is the town of Benton, Mono County, California. Vehicular access to the site is on the partially paved White Mountain Estates Road (formerly Tungsten Road) that extends approximately one mile due east from U.S. Highway 6 (Figure 2; Appendix A). The site is immediately adjacent to and east of a residential subdivision known as White Mountain Estates, Tract 37-16.

### 2.2. PHYSIOGRAPHIC SETTING

The site is located within the Northern Owens Valley, an elongate depression between the Sierra Nevada to the west and the White Mountains to the east. The valley constitutes the westernmost down-dropped block of bedrock (graben) of the Great Basin and Range geomorphic province. It is bound on the west and the east by steep-sided mountain blocks (horsts) along steep dipping normal faults. Based on geophysical and structural information, the Owens Valley is divided into two structural basins, namely the Bishop Basin in northern Owens Valley and the Owens Valley Basin to the south. The site is located within the Bishop Basin.

### 2.3. GEOLOGIC SETTING

Bishop Basin is filled with Quaternary-age sedimentary deposits and interstratified volcanic rocks that comprise the valley-fill (Danskin, 1988 and 1998). The predominant source of alluvial valley fill is from the White Mountains, which rise as much as 10,000 feet above Chalfant Valley. The deposits consist of a heterogenous mixture of gravel, sand, silt, and clay. The interstratified volcanic layer is the Bishop Tuff deposit, which outcrops to the west as the Volcanic Tableland. The Bishop Tuff deposit is composed of pumice and welded ash derived from a volcanic eruption from Long Valley approximately 764,000 ± 5,000 years ago (Izett and Obradovich, 1994). The Volcanic Tableland is terminated to the south by an erosional scarp cut by the Owens River. Although it has been warped by faulting and eroded by the Owens River, the Bishop Tuff is found in the subsurface beneath the valley-fill well south of the present-day limit of its bluff-shaped outcrop (Pinter, 1992). The surface of the Fish Slough block, once at an elevation as high as the tableland, has down dropped beneath both the level of the Owens River floodplain and the water table that underlie the base of the Bishop Tuff. Several meters of sediment now overlie the buried block (Pinter, 1992).

Basement rocks in the adjacent White Mountain range to the east are composed of lower Paleozoic and Precambrian rocks (Hanson, 1987) associated with younger Mesozoic metasedimentary and volcanic rocks (Beanland and Clark, 1994). Basement rocks of the Sierra Nevada to the west are dominantly quartz monzonite of the Cretaceous-age Sierra Nevada batholith. Plutons of the Sierra Nevada batholith underlie large areas of the White Mountains and range in composition from gabbro to quartz monzonite to quartz diorite. Correlation of the plutons across Owens Valley (Ross, 1962) suggests that the same batholithic rock is continuous across the valley, but it is buried beneath the Owens Valley fill.

Large coalescing alluvial fans extend out into Owens Valley from both the Sierra Nevada and the White Mountains (Beaty, 1963; Pinter, 1992). Pleistocene glacial deposits extend beyond the range front of the Sierra Nevada and are apparently correlative with the major fan building episodes that extend west from the White Mountains (Gillespie, 1982). The site is located on a faulted alluvial fan that extends out from the White Mountains between Piute Canyon to the north and Coldwater Canyon to the south. The alluvial fan ranges in age from Pleistocene to Holocene (Bateman, 1966), as shown on Figure 3 (Appendix A). Geologic Cross Section A' – A" (Bateman, 1966) coincides with the southern property line of the subject site, and a copy is provided on Plate 2 (Appendix B).

### 2.4. TECTONIC SETTING

The White Mountain APEFZ fault zone traverses directly through the central section of the site and extends from the Milner Canyon alluvial fan southward to the Waucoba Embayment (dePolo and Ramelli, 1987). The central section contains the ground fracturing associated with the $M_S$ = 6.2 July 1986 Chalfant Valley earthquake (dePolo and Ramelli, 1987; Smith and Priestly, 1988). Ground rupture demonstrated 4 inches of right-lateral oblique-normal offset over a length of 8 to 9.4 miles measured from Silver Canyon north to Sacramento Canyon (dePolo and Ramelli, 1987; Lienkaemper et al., 1987). The APEFZ fault zone is approximately 2,000 feet wide at the south edge of the site and widens to 2,600 feet at the northern property line (Figure 2; Appendix A). The zone trends along and slightly west of the mountain front within alluvial fan deposits. Traces of the central segment are characterized by linear and shutter ridges, uphill-facing scarps, and right-laterally offset stream channels. According to the 1997 UBC, the White Mountain frontal fault is about 105 km in total length, has a slip rate of 1.0 mm/yr, has an $M_{MAX}$ = 7.1, and a recurrence interval of approximately 1,224 years.

Approximately seventeen miles west of the subject site is the Round Valley fault zone (Bryant, 1984b and 1984e), which marks the exact boundary between the Sierra Nevada and the Basin and Range geomorphic provinces. The Round Valley fault is well-defined along the eastern range front of the Sierra Nevada eastern escarpment with topographic relief between Round Valley and the Wheeler Crest ridge top of about 6,700 feet (Chen & Associates, 1987). Regional gravity and seismic-refraction profile studies (Pakiser, 1964; Bateman, 1965) indicate that the alluvial valley-fill in Round Valley is at least 2,000 feet thick suggesting that about 8,700 feet of vertical displacement has occurred since the Quaternary to the present at this locality. Late Pleistocene activity on the Round Valley fault is indicated by offset Tioga-age glacial moraines. Historical activity on the fault is evidenced by the $M_L$ = 6.1 1984 Round Valley earthquake (Smith et al., 1988). A slip rate of 1 mm per year is estimated based on offset Tioga moraines (Clark et al., 1984).

Approximately twenty one miles south is the northernmost extend of the Owens Valley fault zone, which extends nearly continuously from Owens Lake to just south of Bishop. The overall sense of movement on the Owens Valley fault is right-lateral with an average strike of N 20° W. Past studies (Lubetkin and Clark, 1988; Hollett, et al., 1991; Beanland and Clark, 1994) have indicated that late Quaternary movement along the Owens Valley fault has been dominantly right-lateral with lesser amounts of normal displacement occurring near the Alabama Hills near Lone Pine. Traces of the Owens Valley fault are marked by lineaments, groundwater barriers, simple fault scarps, echelon and side-stepping scarps, depressions, pressure ridges and warped and tilted surfaces (Beanland and Clark, 1994). The most recent surface rupture observed on the Owens Valley fault zone occurred on March 26, 1872. This rupture accompanied one of the three largest earthquakes in California's history, estimated at a Richter magnitude of approximately $M_L = 8$ (Oakeshott et al., 1972; Beanland and Clark, 1994). Surface rupture resulting from that event was mapped at 100±10 kilometers. Average right-lateral offset is estimated at about 6 meters with a maximum of about 10 meters at Lone Pine (Beanland and Clark, 1994). Beanland and Clark (1994) roughly estimate the average net slip rate of the Owens Valley fault zone as a whole at 2±1 mm/yr. Also, based on correlation with calculated recurrence dates on other faults in the Owens Valley fault zone, such as the Lone Pine fault (Lubetkin and Clark, 1988) and the Fish Springs fault (Martel et al., 1987) Beanland and Clark tentatively estimate a recurrence interval on the Owens Valley fault of 3,300 to 5,000 years, although additional data is needed to establish greater certainty of this estimate. The northernmost extent of the Owens Valley fault zone is located approximately just north of Big Pine, but it appears to project northward through the center of northern Owens Valley and to be continuous with the Fish Slough fault zone within the Bishop Tuff Volcanic Tableland.

Faulting on the Bishop Tuff Volcanic Tableland presents a long-term record of surface rupture along what is probably the northern extension of the Owens Valley fault zone, particularly in the vicinity of the Fish Slough fault (Pinter, 1992). Faulting is pervasive across the tableland with scarps tens of meters high with predominant trends of N 10-20° W. In general, the fault scarps dip steeply at 60±10° with normal offset. The tableland records at least 40 to 100 earthquake events with magnitudes equal to the 1872 Lone Pine earthquake and a recurrence interval of not more than 7,600 to 18,500 years suggesting an average magnitude earthquake of M = 7.2 has occurred at least 257 times in the last 764,000 years for an average recurrence interval of approximately 3,000 years (Pinter, 1995). The 3,000-year earthquake recurrence interval estimate is consistent with faulting of a Holocene-age Owens River terrace located just south of the tableland. The largest continuous fault (18 to 30 km) across the tableland is the Fish Slough fault, which forms the east boundary of Fish Slough, now a protected wetlands ecosystem. The slip rate for the Fish Slough fault is estimated at 0.16 mm per year (dePolo et al., 1993).

### 2.5. HYDROGEOLOGIC SETTING

Faults within the northern Owens Valley often act as groundwater barriers, which are often evidenced by springs emanating from the ground at an elevation where groundwater can flow over the barrier. Several springs are located on the site, particularly at locations where phreatophytic vegetation grows along zones of elevated groundwater in contrast to the native desert scrub. Two springs are mapped on the enclosed Site Geologic Map (Plate 1).

A geologic log of the onsite water production well located at the western end of the site indicates that in July 2004, static groundwater was measured at depth of approximately 200 feet below the ground surface (bgs). The ground elevation at the well head is at approximately 4,403 feet above mean sea level. A copy of the water well log prepared by GS Environmental is provided in Appendix C. The groundwater gradient generally trends westerly towards Chalfant Valley. Both permanent and perched groundwater levels on the subject site fluctuate seasonally.

### 2.6. SURFICIAL SOILS SETTING

A review of the U.S. Department of Agriculture's "Soil Survey of Benton-Owens Valley Area, California, Parts of Inyo and Mono Counties" (Tallyn, 2002) indicates that the site is located on the "General Soil Map" within an area mapped as "Yermo-Seaman-Yermo, Stony", which are thermic soils on alluvial fans and fan terraces with very deep, well-drained, nearly level to strongly sloping soils that formed in mixed alluvium. A review of the "Detailed Soil Map" in the same report indicates that two distinct soil units underlay the site. The soil within the westernmost and easternmost portions of the site are classified as Cambidic Haplodurids-Typic Haplodurids, which are younger fan terrace alluvial soils generally derived from mixed rock sources containing 15 percent contrasting inclusions, and with calcareous chemical properties yielding slight to moderate alkaline reactions (pH=7.4 to 8.4). According to the survey, typical engineering index properties include Unified Soil Classification System (USCS) gravel, gravelly soils, sand and sandy soils symbolized by GP, GP-GM, GM, SM, and SP-SM between 1 to 60 inches in depth, respectively. Cambidic and Typic Haplodurids typically have a Liquid Limit between 15-25% and a Plasticity Index of NP-5.

The central-most portion of the site exhibits the highest topographic relief, and it is underlain by a second distinct soil referred to as the "Yermo" and the "stony-Yermo" complexes (Tallyn, 2002). These are older fan terrace alluvial soils containing 15 percent contrasting inclusions, and they are derived predominantly from metasedimentary sources (White Mountains). Yermo soils have stronger calcareous chemical properties that yield moderate to strong alkaline reactions (pH=7.9 to 9.0). Typical engineering properties include USCS gravel, gravelly soils, sand and sandy soils symbolized by SM, GC-GM, GP-GM, GC, GM, SP-SM, SM and GM between depths of 1 to 60 inches, respectively. Yermo and stony-Yermo soils typically have a Liquid Limit between 20-30% and Plasticity Indices of NP-5 and NP-10, respectively. For more detailed descriptions regarding soil development on the site, refer to the trench logs found in Appendix E.

# 3.0. SITE INVESTIGATION

## 3.1. METHODOLOGY

Methods used to investigate conditions at the project site included review of published geological literature (as described in the previous sections), an aerial photographic analysis, a site reconnaissance, a subsurface investigation (trenching), and a probabilistic seismic hazard analysis.

## 3.2. AERIAL PHOTOGRAPHIC ANALYSIS

Aerial photographs on file with the Los Angeles Department of Water and Power (LADWP) were reviewed for this study. The photos were clear, of high quality, and they were viewed in stereo. In order to reduce bias, no fault traces and lineaments are plotted on the photographs. Copies of the photographs are included as Plates 3 – 9 in Appendix B. The following are descriptions of the photographic analysis:

*Plate 3. 10/17/1944, Fairchild, OV 4-113, scale 1:24,000, black & white, stereo, fair resolution*

The White Mountain APEFZ is apparent through the subject site with well-defined scarps and prominent tonal lineaments that are coincident with the faults and cracks mapped by Bryant (1984), Davis (1985), Kahle et al. (1986) and dePolo and Ramelli (1987); two west-flowing ephemeral streams appear offset right-laterally; two north-south-trending scarps are apparent with one having significant west-side-down displacement; a prominent north-south-trending shutter-ridge bisects the site; other subtle north-south-trending lineaments and aligned saddles are also apparent; all of the above confirmed by subsurface trenching; a total of five significant faults are apparent.

*Plate 4. 10/17/1944, Fairchild, OV 4-114, scale 1:24,000, black & white, stereo, fair resolution*
No changes.

*Plate 5. 8/10/1951, USGS, GS-QN 1-26, scale 1:47,200, black & white, single, fair resolution*
No changes.

*Plate 6. 10/26/1973, LADWP, 463-3, 5-11, 1:40,000?, color, stereo, fair resolution*
The White Mountain APEFZ is shown in greater lateral continuity; intersection through the site is obvious; lighter colored fan features indicate younger deposits, particularly the ponded alluvium located west of the north-south-trending shutter-ridge through the site; younger fan terrace deposits are apparent on the west margins of the site.

*Plate 7. 10/26/1973, LADWP, 463-3, 5-12, 1:40,000?, color, stereo, fair resolution*
No changes.

*Plate 8. 9/14/1990, LADWP, Owens Valley 21A-1, scale 1:12,000, color, single, excellent resolution*
The above features are shown in greater detail as the resolution is much better; more tonal lineaments are apparent – all of which were confirmed as faults, shears or cracks where trenched.

*Plate 9. 9/14/1990, LADWP, Owens Valley 21A-2, scale 1:12,000, color, single, excellent resolution*
No changes.

### 3.2. PREVIOUS WORK

Previous APEFZ work on the specific site is not known; however, a "Fault and Seismic Investigation for Proposed Residential Development, Tract 37-16, Mono County, California" was performed by Ehlert (1999) for the adjacent offsite property to the east. A review of Ehlert's study did not indicate that there was a presence or potential for ground failure due to fault rupture. A second report for the same property titled "Geomorphology and Soil Stratigraphy Investigation, Proposed Addition to White Mountain Estates (Tract 37-16), Mono County, California (Schell, 2001) was also reviewed, and it included a 'Map of Geomorphic Features in Site Vicinity', which covered a significant amount of adjacent property, including the subject site. Several faults were shown to be plotted, eleven of which were mapped across the subject site through Holocene- to early Pleistocene-age soils. A copy of Schell's map is included as Figure 4 (Appendix A).

Previous work was also performed on subject the site by the State of California as documented by Bryant (1984a), whereby recent faulting is indicated by tonal lineaments, vegetation contrasts, troughs, and offsets in late Pleistocene alluvium. According to Bryant, a scarp height measuring 4.6 meters was found on the site. Bryant also published a second report (Bryant, 1984b) that describes the White Mountain frontal fault across the site as “sufficiently active” and “well-defined”, and his recommendation was to place the fault within a zone for special studies. Previous work by Davis (1985), which is essentially a confirmation of the data presented by Bryant (1984a), places the White Mountain frontal fault into an APEFZ, and the zone is shown to intersect the subject site (Figure 2; Appendix A).

Previous work was also performed on subject the site by Kahle et al. (1986) and by dePolo and Ramelli (1987) as part of larger scopes of work related to the investigation of ground surface rupture following the July 21, 1986 Chalfant Valley earthquake. In particular, these two investigations cite evidence and data for ground cracking along two north-south oriented alignments that are located within the eastern portion of the site. Unfortunately, due to the large scale of mapping, precise locations for the mapped cracks did not allow for accurate transfer onto the enclosed Site Geologic Map; however, they appear to coincide with the faulting shown on the APEFZ map shown on Figure 2. According to these two investigations, right-lateral offset of 4.5-5.0 cm was measured in the direction of a fault trend (N 10º W) on left-stepping cracks which trend about N 10º E.

### 3.3. SITE RECONNAISSANCE

A reconnaissance of the project site and surrounding area was performed during the subsurface exploration that began on August 16, 2004. The subject site was inspected for any evidence of surface rupture consistent with the observations noted in the air photo analysis and as mapped by others.

Reconnaissance of the subject site confirmed the presence of the White Mountain frontal fault zone offsetting alluvial fan deposits mapped as mid-Pleistocene (Qof) to Recent (Qyf) per Bateman (1965). Faulting appeared to be well-defined and laterally continuous across the site with prominent fault-generated shutter ridges that are aligned north-south. These features are obvious lineaments in the aerial photos. Two narrow intermittent stream channels containing

Recent alluvial deposits flow across the site from east to west. Both channels are interrupted by a large, centrally-located shutter ridge, and surface runoff has had to flow both to the north and to the south to get around it. Relatively thick accumulations of alluvium are mapped east of the shutter ridge, and relatively young alluvial fans are mapped westerly of the shutter ridge. A prominent fault scarp measuring approximately thirty feet high traverses the eastern portion of the site trending about N10W. Two other less prominent scarps traverse the site at either side of the main scarp and at roughly the same north-south bearing, but they are characterized by aligned ridge saddles, topographic grade breaks, phreatophytes, and offset stream channels.

Reconnaissance of the subject site also revealed the presence of a significant north-south-trending alignment of ground rodent activity traversing the west portion of the site. Many of the larger fragments within the rodent-expelled material were coated with a pedogenic calcite ($CaCO_3$) encrustation, indicating a late Pleistocene age alluvial fan surface as was observed and reported by Schell (2001).

### 3.4. SUBSURFACE FAULT TRENCHING

Nine trenches totaling approximately 3,785 lineal feet with average depths of approximately 5 feet were excavated in an east-west alignment perpendicular to the north-south trend of faulting. The locations of each trench were surveyed in by the Project Surveyor, Bear Engineering, and are shown on Plate 1. Each trench was logged in detail at a scale of 1”=5’, and copies of each original field log are provided as Trench Logs T-1 through T-9 in Appendix E. Trenches T-1 through T-5 were excavated initially, and the remaining trenches were excavated as additional work in order to verify the lateral continuity of the prominent faults found in the initial trenches. The equipment used to excavate the trenches was a Case 740 Extend-A-Hoe with a 24-inch bucket. The trench walls were scraped clean of all ‘bucket smear’ and spoil using a pick, shovel and scraper. Shoring units were determined not to be required. Horizontal stations along the trench at the ground surface were measured using a 300-foot reel tape, and vertical stations were measured using a self-retracting tape. Logging was completed for Trench T-5 on March 10, 2005. All trenches were subsequently backfilled loosely and without water with the excavated materials.

Based on our reconnaissance and subsurface exploration of the site, the faulting, indicated by the aerial photographs and mapped by others, was confirmed. In fact, faulting was found to be much more pervasive across the site than the aerial photographs and previous mapping indicated, so much so that, most of the site cannot be developed for habitable structures. Nevertheless, five significant through-going faults have been delineated, and each fault contains an abundance of subsidiary splays, shears and cracks. Faults #1 through #5 are delineated from west to east across the site on Plate 1. These faults appear to coincide with those that were previously mapped by Bateman (1966), Bryant (1984) and Davis (1985), and they appear correlate to the Chalfant Valley earthquake cracks previously mapped by Kahle et al. (1986) and by dePolo and Ramelli (1987).

The earth materials encountered in the exploratory trenches were categorized into forty-three unique stratigraphic units based on color, grain size, degree of bedding, cementation, and field density, but by-and-large correlate to the soil stratigraphy study performed by Schell (2001). All of the units have characteristics consistent with late Pleistocene to late Holocene ages. Non-faulted bedding was found to be generally horizontal to gently west-dipping, but with steep to vertical to overturned attitudes near and within the faulted zones. Trenches T-5 and T-9 were the only trenches that were widened, benched, and deepened in an attempt to get beneath a thicker alluvium.

All trenches have been or are scheduled to be backfilled loosely with the excavated material; therefore the backfill could be subject to settlement. If trench backfill is encountered during future construction for foundations, the backfill material should be removed and properly compacted. Each trench was surveyed in by the project surveyor, and their exact locations are delineated on Plate 1 (Appendix B).

### 3.4.1. SOIL AGES AND TYPES

According to work performed by Schell (2001), at least five different ages have been assigned to the soils on the subject site. As denoted on Schell's map (Figure 4; Appendix A), these soils are mapped as "Qfo(7)', 'Qfo(6)', 'Qfi(5)', 'Qfi(3/4)', and 'Qfy(2)', with corresponding ages of '>1 million', '200,000-1 million', '35,000-130,000', '15,000-35,000', and '<10,000' years old, respectively. Of these, the youngest soil deposits are found within narrow, intermittent stream channels that transect older established Pleistocene-age alluvial fans. These young deposits form local fans and debris flow deposits at the mouths of small gullies, and they form ponded alluvium behind and up-slope of fault ridges. The oldest deposits are found predominantly within the shutter ridge bodies.

Forty-four unique stratigraphic units were recognized during the subsurface trenching, and they are described in general conformance to the guidelines suggested by Jackson (1970) and by The Rock-Color Chart Committee (1984), which is based on the Munsell system. The stratigraphic units are denoted on the trench logs, and they are listed and summarized with an estimated age as follows:

1. Yellowish gray to grayish orange (5 Y 7/3 to 10 Y 7/2) clast supported angular fanglomerate with silt and fine to coarse sand matrix; very loose; dry; slight to moderate pedogenic development on clasts; unit interpreted to be Recent fan deposit continuous with Qyf mapped by Bateman (1966).
2. Yellowish gray (5 Y 7/3) interbed of silt within #1, with fine to coarse sand, gravel and occasional cobbles up to 3" diameter; loose to moderately dense; dry; Recent age.
3. Yellowish gray to grayish orange (5 Y 7/3 to 10 Y 7/2), silt with very fine sand and trace of coarse sand and cobbles of slate; $CaCO_3$-cemented, dense (moderately dense where poorly cemented); moist (10 YR 5/3 to 5/4 when moist); $CaCO_3$ precipitates on trench wall surface; interpreted to be Recent age alluvium ponded behind shutter ridge.
4. Pinkish light brown (5 YR 6/2) crack and fault infilling and breccia; very fine to coarse sandy silt; loose (dense where cemented).
5. Yellowish gray to grayish orange (5 Y 7/3 to 10 Y 7/2), silt with clay and trace coarse sand, gravel and cobbles up to 3" diameter; partially cemented, broken and shattered horizontally giving false appearance of bedding; interpreted to be Recent age alluvium ponded behind shutter ridge.
6. Dusky yellow (5 Y 6/5), fine sandy silt with trace clay to silty fine sand with trace clay; moderately dense; wet; local mottling; local organic-rich interbeds; interpreted to be Recent age alluvium ponded behind shutter ridge.
7. Dark yellowish brown (10 YR 4/2) to dark yellowish orange (10 YR 6.5/5), fine to coarse sandy gravel with cobbles up to 12" diameter; moderate pedogenic development; weakly cemented; moist; organic-rich; interpreted to be older fan deposit.
8. Grayish yellow (5 Y 8/1), travertine bed, interbed or nodules composed of fine-grained sand with trace slate clasts; very dense; interpreted to have originated from local onsite spring runoff over ground surface, probably Pleistocene to Recent age.
9. Moderate orange pink (10 R 7/2 to 7/3) topsoil composed of silty very fine eolian sand with medium to coarse sand and trace gravel; loose to moderately dense; heavily rooted in upper 3"; interpreted to be Recent age.
10. Moderate yellowish brown (10 YR 5/4) soil composed of silty, very fine to fine sand with coarse sand and gravel; loose; moist; organic-rich; porous; rooted; interpreted to be

Recent age topsoil.

11. Pale yellowish brown (10 YR 6/2) soil composed of silty to very fine to fine sand with coarse sand and gravel; minor to moderate cementation; slight bifurcation; moderately dense to dense; moist; rooted in cracks; porous; interpreted to be A-Horizon soil.
12. Moderate grayish orange pink (5 YR 8/1) soil composed of silty, very fine to fine sand with coarse sand and gravel; moderate to well cemented; porous; fractured parallel to ground surface; possibly a Bt-Horizon soil.
13. Grayish orange pink (10 R 8/2), very fine to fine eolian sand; trace local cementation with very slight induration; interpreted to be youngest Recent age.
14. Pale greenish yellow (10 Y 8/1) very fine sandy silt with gravelly silt interbeds; moderately dense with slight cementation; interpreted to be Recent alluvium ponded behind shutter ridge.
15. Very pale orange (10 YR 8/1), silty very fine to fine sand with coarse sand and gravel up to 2” diameter; very loose; cemented near faults; interpreted to be Recent age.
16. Pale grayish orange (10 YR 7/3) silty very fine sand with interbeds of gravel up to ½” diameter; local cross-bedding in sand; moderately dense; interpreted to be Recent age.
17. Very pale orange (10 YR 8/2), gravel and cobbles up to 6” diameter with very fine to coarse sandy silt matrix; weakly to moderately cemented; weakly bedded; moderately imbricated with 90% slate clasts with slight to moderate pedogenic development.
18. Very pale grayish orange (10 YR 8/2.5) A-horizon soil composed of silty, very fine sandy gravel and cobbles up to 4” diameter with medium to coarse sand and clay; slightly to moderately dense; slightly to moderately indurated; faint stratification of gravels; Recent age.
19. Very pale orange (10 YR 8/2) soil composed of silty very fine to fine sand with medium to coarse sand and trace clay and gravel; dense; well indurated; slightly cemented; porous; ponded alluvium resembles Bt-Horizon soil of late Pleistocene age.
20. Very pale orange (10 YR 8/1) to pale grayish yellow (5 Y 8/2) silty, very fine sand, gravel and cobbles up to 24” diameter with trace clay; moderate to well-bedded to graded interbeds composed of 90% angular to sub-rounded slate; loose to moderately dense; trace to moderate cementation pedogenesis on clast bottoms; imbricated; matrix supported; similar to #1; Recent to Pleistocene age Qyf.
21. Pale grayish yellow (5 Y 8/2) silty very fine sand with 10% fine to coarse sand and gravel up to 1” diameter; interbeds of silty to very fine to coarse sandy gravel and cobbles up to 1” diameter; approximately 2% coarse sand composed of white pumice clasts; weakly cemented; dense; late Pleistocene age.
22. Very pale orange (10 YR 8/1) cobble conglomerate with boulders up to 20” diameter; mostly clast supported with very fine sandy silt matrix; loose; Pleistocene age Qof.
23. Pale yellowish gray (5 Y 7/1) very fine to coarse sandy silt with trace clay; moderately dense; crumbly upon dessication; late Pleistocene age.

24. Very pale orange (10 YR 8/2) silty very fine sand with 10% fine to coarse sand and gravel up to 1" diameter; interbeds of silty to very fine to coarse sandy gravel and cobbles up to 1" diameter; approximately 5% coarse sand composed of white pumice clasts; weakly cemented; dense; late Pleistocene age.
25. Grayish pink (5 R 8/2) very fine to fine sand with 30% medium to coarse sand, 5% gravel and angular to rounded cobbles up to 4" diameter; moderately well-bedded with depth; late Pleistocene age.
26. Yellowish gray (5 Y 7/2) silty fine to coarse sand with gravel up to 1" diameter; poorly to moderately cemented; moderately dense to dense; late Pleistocene age.
27. Very pale orange (10 YR 8/1) to grayish moderate orange pink (5 YR 8/1) silty fine to coarse sand to sandy gravel; matrix supported; well bedded; moderately dense to dense; moderately cemented; late Pleistocene age.
28. Grayish moderate orange pink (5 YR 8/1) to very pale orange (10 YR 8/1) silty fine to coarse sand with up to 40% gravel and cobbles up to 6" diameter; moderately dense; slightly cemented; some gravel beds composed of 90-95% white pumice; late Pleistocene age.
29. Very pale orange (10 YR 8/2) to grayish orange (10 YR 7/4) fine to coarse sandy silt with 5% clay matrix and gravel and cobbles up to 24" diameter; moderately well-bedded with local interbeds; very dense; indurated; imbricated; Pleistocene age Qof.
30. Pale grayish orange (10 YR 7/2) slopewash composed of silty fine to medium sand matrix with coarse sand, gravel and cobbles up to 6" diameter; loose; massive to weakly bedded; rooted to depth; Recent age.
31. Dusky yellow (5 Y6.5/3) to moderate yellow (5 Y 7/3 to 7/4) coarse sandy conglomerate with cobbles up to 24" diameter; clast supported; imbricated; moderate pedogenic development; well cemented in lenses and layers; matrix composed of fine to medium sandy silt with trace clay; slightly loose; late Pleistocene age.
32. Pale grayish orange (10 YR 7/2) fine to medium sandy silt with 5-10% clay and with cobbles up to 12" diameter; moderately dense to dense; porous; pervasively rooted; cemented nodules throughout; resembles Bt soil horizon; late Pleistocene age.
33. Pale grayish yellow (5 Y 8/2) very fine to fine sandy, clayey silt with a medium to coarse sand matrix and cobbles up to 6" diameter; moderately dense; moderately to well indurated; porous; pervasively rooted; resembles A-horizon soil; Recent age.
34. Pale yellowish brownish orange (10 YR 6/3) very fine sand to coarse sandy silt matrix with cobbles up to 4" diameter; massive; loose; rooted; Recent age.
35. Very pale orange (10 YR 8/2) sandy silt (similar to #20) and gravel up to 3" diameter; matrix supported; massive; $CaCO_3$ precipitation on trench wall immediately upon excavation; loose to moderately dense; Recent age Qyf.
36. Grayish moderate orange pink (5 YR 8/1) mottled with moderate yellow (5 Y 7/6) very fine to coarse sand and gravel with trace cobbles up to 6" diameter; matrix supported being derived from Bishop Tuff; massive to weakly bedded; loose to moderately dense; late

Pleistocene age ponded alluvium.

37. Pale grayish brownish orange (10 YR 6/4 to 10 YR 7/2) silty fine to medium sand with coarse sand and 20% gravel derived from Bishop Tuff; trace cobbles; loose; porous; rooted; $CaCO_3$ precipitation on trench wall immediately upon excavation; Recent age.
38. Grayish yellow (5 Y 8/4) silty fine sand with medium to coarse sand and trace clay and gravel; laminated; loose to moderately dense; moderate cementation; $CaCO_3$ precipitation on trench wall immediately upon excavation; late Pleistocene age.
39. Pale grayish orange (10 YR 7.5/2) fine sandy silt matrix with coarse sand, gravel and cobbles up to 4" diameter; angular to rounded; loose to moderately dense; poorly to well bedded; Pleistocene to Recent age Qyf.
40. Pale grayish orange (10 YR 7.5/2) gravel and cobbles with fine sandy silt matrix; clast supported; angular to rounded; poorly bedded to massive; loose to moderately dense; Pleistocene to Recent age Qyf.
41. Grayish dusky yellow (5 Y 6.5/3) silty fine sand with trace to 10% coarse sand and gravel; irregular beds and interbeds within #20 and #31; moderately dense; pervasively rooted; Recent age ponded alluvium.
42. Very pale orange (10 YR 8/2) silty fine sand interbedded and laminated with silty fine to coarse sand with gravel and cobbles; thin laminae of $CaCO_3$ cementation along bedding; discontinuous organic layers throughout; loose to moderately dense; porous; resembles Bt horizon soil; late Pleistocene age.
43. Pale grayish orange (10 YR 7.5/2) fine sand with trace clay; clast supported with angular slate gravel; well bedded and cross-bedded; pedogenic development witnessed on pebbles while trenching; moderately dense; rooted.
44. Pale grayish orange (10 YR 7/2) medium to coarse sand and sandy gravel with gravel to cobble interbeds; clast to matrix supported; matrix is fine sand; moderately dense; loose to touch; slight to moderate pedogenic $CaCO_3$ on most clasts; most of moderate pedogenesis is a result of reworking older alluvium; Recent age alluvium.

Nearly all of these units were either cracked or faulted to some degree. Refer to the enclosed trench logs for more details regarding any measured offsets and relative age relationships.

### 3.4.2. SITE FAULTING

Active (Recent; ≤11,000 years old) faulting across the site was revealed in all of the trenches at specific locations where Recent topsoil, Recent A-Horizon soil and/or Recent alluvium was determined to be cracked, faulted and/or offset. Recent alluvium was observed to be offset in Trenches T-2, T-5 and T-7 only. The following trench stations list where Recent age materials were observed to be faulted and/or cracked:

| | |
|---|---|
| Trench T-1. | Topsoil cracked and faulted between stations 160 and 220. |
| Trench T-2. | Recent eolian deposit and underlying A-Horizon soil cracked and faulted at stations -79.5, -68, -40 and -18.5; faulted alluvium (ponded behind shutter ridge) between stations 80 thru 158. |
| Trench T-3. | Topsoil offset between stations 19 thru 72.5 and 118 thru 224. |
| Trench T-4. | Topsoil offset between 19 thru 63.5, 94-123.5 and 161 thru 285.5; < 1 cm of right-lateral offset on minor left-stepping cracks reported by Kahle, et al. (1986). |
| Trench T-5. | Topsoil offset between stations 3 thru 20, at stations 40 and 78, between stations 158 thru 268.5, and between stations 322.5 thru 350; Recent age alluvium cracked at stations 434 and 449.5; Recent age alluvium faulted at stations 350 and 356. |
| Trench T-6. | Topsoil cracked and/or faulted between stations -1.5 and 33.5, at station 80, from stations 297 thru 370, and from stations 396 thru 538.5. |
| Trench T-7. | Topsoil offset at stations 22 and 48; past grading operations at old mill site removed topsoil from stations 49 thru 243 even though faulting appears Recent; preserved topsoil entrained into fault at station 199; suspect bedding attitudes in Recent deposit (slopewash/colluvium?) from stations 220 thru 250; cracked slopewash at station 287; faulted Bt-Horizon soil at station 513. |
| Trench T-8. | A-Horizon soil faulted from stations 51.5 thru 53, stations 70 thru 84, and stations 194.5 thru 218; A-Horizon soil cracked at station 246. |
| Trench T-9. | Topsoil cracked and/or faulted from stations 8.5 thru 12, at station 36, 50, 75, 88, 115, and finally at station 145. |

Refer to the notes that are provided on each trench log sheet for additional details.

## 4.0. SECONDARY EARTHQUAKE HAZARDS

The potential for secondary geologic hazards that can be associated with a relatively large earthquake include shallow ground rupture, soil lurching, liquefaction, and seiches and tsunamis. These secondary effects are discussed in the following sections.

### 4.1. GROUND RUPTURE

Regarding ground rupture, a review of California Geological Survey Special Publication 42 (Hart, 1999) indicates that an active earthquake fault based Alquist-Priolo criteria is zoned across the subject site. Although new fault exposures may develop during a seismic event, significant ground rupture is generally expected to occur along pre-existing fault breaks. Ground rupture cannot be prevented, therefore mitigation of the hazard involves identifying the major faults that may produce ground rupture, and avoiding construction over their surface traces. Ground rupture on the subject site was recognized by reviewing published literature, field mapping, aerial photo evaluation, and subsurface fault exploration. The enclosed Site Geologic Map (Plate 1; Appendix B) and Geologic Cross Section A-A' (Plate 2; Appendix B) illustrate the underlying three-dimensional geology of the active faults and associated sub-faults, splays and ground cracking that were encountered during our investigation. As our investigation revealed, the subject site is pervasively faulted; however, a few areas large enough for habitable structures were found. According to Hart (1999), the area within 50 feet of an active fault is presumed to be underlain by active branches of the fault, unless proven otherwise. As revealed from our geologic trenching, the active branches of the five most significant active faults across the site have been accounted for through geologic logging and by Global Positioning Satellite survey. Therefore, building setback lines measuring a minimum of twenty-five feet from parallel to and the logged and surveyed active faults have been delineated and color-coded green on the Site Geologic Map. The non-faulted areas in-between the building setback lines are also color-coded green and noted as proposed "Habitable Zones".

### 4.2. GROUND LURCHING

Ground lurching refers to the rolling motion on the ground surface generated by the passage of seismic surface waves. Effects of this nature are likely to be most severe where the thickness of soft sediments varies appreciably under structures. In its present condition, the potential for lurching below the habitable zones is considered low due to the potentially compressible soils within the upper few feet of material below existing grades. The potential for lurching may be further reduced if the topsoil on site is removed and properly compacted during development.

### 4.3. GROUND SHAKING

Ground shaking is generated during an earthquake when two blocks of the earth's crust break and slip against each other. The intensity and duration of ground shaking felt at a given site are primarily a function of the magnitude of an earthquake and the attenuation of the seismic energy from its source or hypocenter. The attenuation of earthquake energy is a function of the elasticity (absorbability) of the materials through which it passes. Ground shaking generally increases with increasing magnitude and is greatest at or near the epicenter and attenuates with increasing distance. Three methods used to evaluate for future potential ground shaking on a given site are 1) review of ground motions recorded during historic earthquakes, 2) deterministic seismic hazard analysis, and 3) probabilistic seismic hazard analysis. The scope of this evaluation employs all three methods, and they are presented in Sections 4.6 and 4.7 of this report.

Historically, several moderate and major earthquakes have occurred in the Owens Valley region. Based on the historic record, it is reasonable to postulate that large earthquakes will occur again in the Owens Valley region to produce strong ground shaking at the subject site. Regionally, several moderate and major earthquakes have occurred within a north-trending seismic belt known as the Central Nevada and Eastern California seismic belt (dePolo et al., 1993). This belt is coincident in part with the Mono Basin-Long Valley-Owens Valley regions. All of the major earthquakes that have occurred in this belt have produced surface ruptures that extend over tens of kilometers in length with ground motions widely felt across the western United States. Within this belt, however is a gap, termed the White Mountain Seismic Gap, of relatively low seismicity during historical time. The White Mountain Seismic Gap occurs between the 1872 Owens earthquake (M = 8.3) event near Independence and the 1932 Cedar Mountain earthquake (M = 7.2) event in western Nevada. Even though seismicity within this gap has accelerated following the 1978 Swall Meadows earthquake (M = 5.7), it is likely that at least two earthquakes of magnitudes greater than 7.0 will be required to bring the gap into equilibrium with the remainder of the seismic belt (dePolo et al., 1993). Major or significant earthquakes felt in the vicinity of the subject site (Chalfant Valley earthquake sequence) have usually originated from faults located in the immediate area of Bishop.

### 4.4. LIQUEFACTION

Liquefaction is most common in relatively young soils of low cohesion that are saturated by groundwater, with a ground water level less than 50 feet below the ground surface. Alluvium of low cohesion may exist locally in the subsurface on the subject; however, depth to permanent ground water has been measured at over 200 feet below the ground surface. Therefore, the potential for liquefaction to occur on the site is considered very low. A detailed liquefaction potential analysis and earthquake-included settlement calculations were outside the scope of services for this study and, therefore, were not conducted for the subject site. Localized strata of relatively loose, clean, silty, fine- to medium-grained sands may exist below the onsite high groundwater depth and may be liquefiable, as is the case for the ponded alluvium located along Fault #4 just west of the onsite springs; however, this has been mapped as a non-habitable area. In the event of the design level earthquake, liquefaction of these soils may locally reduce the factor of safety against liquefaction, causing settlement to occur.

### 4.5. LATERAL SPREADING AND DYNAMIC SETTLEMENT

Geologic materials of significantly different properties (i.e. cohesion, cementation, density, moisture, constructed cut/fill contacts, etc.) can experience differential movement and dynamic settlement in response to earthquakes events. Side-hill fills placed on an incline in particular may settle toward equilibrium (lateral spreading) more so than a fill mass placed on horizontal ground. Where graded contacts between man-made fills and natural alluvium/bedrock exist, a potential for differential settlement may occur due to the different shaking characteristics between them. Man-made fills will vibrate at a different frequency and/or out of phase with the adjacent alluvium/bedrock; therefore, significant ruptures can occur along their contact during an earthquake. Poorly consolidated materials, particularly alluvium, may experience settlement (dynamic compaction) due to seismic shaking. Total dynamic settlement as well as differential settlement may exceed the tolerances calculated by a structural engineer for any proposed structures.

### 4.6. SEICHES AND TSUNAMIS

The potential for seiches in lakes and seas or ocean tsunamis to impact the subject site are considered to be non-existent due to the extraordinarily large distance of such large open bodies of water from the site.

### 4.7. SLOPE FAILURES AND LANDSLIDES

Potential hazards from landslides are likely to occur within steep hillside terrain that may be prone to failure during seismic events, particularly when wet or saturated. Earthquakes can disturb mass equilibrium that is close to instability and can accelerate ongoing landslide movement or reactivate slipped masses that had previously stabilized. Weaker earthquakes with higher frequencies can trigger surficial rock falls and soil slips on steep slopes. Slope failures generally occur because of an increase in shear stresses in the slope mass and/or because of a decrease in cohesive strength under dynamic loading conditions (Cotecchia, 1987).

Three surficial landslides were recognized during our investigation, and they are shown on the enclosed Site Geologic Map (Plate 1; Appendix B). Landslide susceptibility on the site is considered moderate; however, since the proposed Habitable Zones are located outside the landslide-prone areas, landslides are not anticipated to be a hazard to the proposed development.

# 5.0. SEISMIC ANALYSES

Site coordinates of latitude 37.4936° north and longitude 118.3379° west were estimated using the website Topozone.com. Computer programs written and published by Blake (2000) were used to estimate peak horizontal accelerations from regional faults, to tabulate data from historical earthquakes, to estimate the Design Basis and Upper Bound earthquakes, and to calculate Uniform Building code design criteria.

## 5.1. DETERMINISTIC ANALYSIS

A deterministic seismic analysis was performed within a 62.2 mi (100 km) radius of the site using the computer program **EQFAULT** (Blake, 2000). The results of the analysis indicate that the peak ground acceleration estimated for a maximum earthquake event within the specified radius is 0.49g. This acceleration represents deterministic peak ground accelerations and could occur from a magnitude 7.1 ($M_W$) earthquake on the White Mountains fault located approximately 0.0 mi (0.0 km) from the site. The Fish Slough fault, located approximately 2.9 mi (4.6 km) from the site could produce a magnitude 6.7 ($M_W$) earthquake resulting in a peak horizontal ground acceleration of 0.38g at the site. The tabulated results of the deterministic seismic analysis are presented in Appendix D.

## 5.2. HISTORICAL ANALYSIS

The computed maximum site acceleration within a 62.1 mi (100 km) radius of the site was derived from **EQSEARCH** (Blake, 2000) during the time period of 1800 to 2004. The largest estimated site acceleration based on the Boore et al. (1997) model, was 0.28g, which occurred during the Chalfant Valley earthquake on July 21, 1986. This earthquake was located approximately 2.3 mi (3.8 km) from the site. The Modified Mercalli Intensity and earthquake magnitude were IX and 5.9 ($M_w$) respectively. The largest earthquake recorded within the specified distance and time period was a magnitude 7.8 ($M_W$) earthquake (Modified Mercalli Intensity of VII) which occurred in The Owens Valley on March 26, 1872 approximately 56.3 mi (90.7 km) from the site. The tabulated results of the historical analysis are presented in Appendix D. The Earthquake Epicenter Map, which depicts the epicenters and magnitudes of historical earthquakes that have affected the site, an Earthquake Recurrence Curve, and a plot depicting Earthquake Events versus Magnitude are also presented in Appendix D.

### 5.3. PROBABILISTIC ANALYSIS

The computer program **FRISKSP** (Blake, 2000) was used to perform a probabilistic analysis of seismicity at the subject site. The probabilistic analysis was used to define the Upper-Bound and Design Basis Earthquakes at the site for use in structural design. These results, as well as Probability of Exceedance versus Acceleration plot and a Return Period versus Acceleration plot, are presented in Appendix D. Based on the results of the probabilistic analysis, the calculated ground acceleration from the Upper-Bound Earthquake (Non-Magnitude Weighted) for the site, defined as the ground motion that has a 10-percent chance of exceedance in 100 years, with a statistical return period of ~ 949 years, is 0.45g. Calculated ground acceleration on the site from the Design Basis Earthquake (Non-Magnitude Weighted), defined as the ground motion that has a 10-percent chance of exceedance in 50 years, with a statistical return period of ~ 475 years, is 0.34g. Results from these analyses are also presented in Appendix D.

### 5.4. SEISMIC DESIGN ANALYSIS

Table 1 presents the Seismic Parameters for use in preparing a Design Response Spectra for the site. The program used to obtain the seismic parameters is **UBCSEIS**, which is based upon the 1997 Uniform Building Code (UBC) and 2001 California Building Code (CBC).

The subject site is situated in Seismic Zone 4 (Z=0.4) based on the 1997 UBC, and the 2001 CBC. A geologic subgrade type $S_D$ "Stiff Soil" was assumed for the site. The Boore et al. (1997) NEHRP C (520) acceleration-attenuation relation was used to estimate ground accelerations at the site. The seismic coefficients of acceleration and velocity $C_a$ and $C_v$, as derived from the soil profile type and seismic zone factor, are 0.57 and 1.02, respectively.

The distance between the site and the nearest active fault is less than 1 mi (2 km); therefore the near-source acceleration and velocity factors $N_a$ and $N_v$ are 1.3 and 1.6 respectively. The nearest known active fault is the White Mountains fault located approximately 0.0 mi (0.0 km) from the site. The White Mountains fault is a Type B Seismic Source.

**TABLE 1**

| UBC-CHAPTER 16 TABLE NO. | SEISMIC PARAMETER | RECOMMENDED VALUE |
|---|---|---|
| 16-I | Seismic Zone Factor Z | 0.4 |
| 16-J | Soil Profile Type | $S_D$ |
| 16-Q | Seismic Coefficient $C_a$ | 0.57 |
| 16-R | Seismic Coefficient $C_v$ | 1.02 |
| 16-S | Near Source Factor $N_a$ | 1.3 |
| 16-T | Near Source Factor $N_v$ | 1.6 |
| 16-U | Seismic Source Type | B |

Conformance to the above criteria for strong ground shaking does not constitute any kind of guarantee or assurance that significant structural damage or ground failure will not occur during a large magnitude earthquake. Design of structures should comply with the requirements of the governing jurisdictions, building codes, and standard practices of the Association of Structural Engineers of California. A Design Civil or Structural Engineer in conjunction with the State Architect should determine what level of risk is acceptable for the project considering the recommendations contained in this report, economics, and safety.

## 6.0. CONCLUSIONS AND RECOMMENDATIONS

The following is a summary of our conclusions, professional opinions and recommendations based on the data reviewed:

1. Based upon review of available data, field exploration and geologic analysis, it is our opinion that the subject site is suited and safe for the use intended from a geologic standpoint, provided the following are considered and incorporated during planning and construction.
2. Building setback lines measuring a minimum of 25 feet and corresponding “Habitable Zones” have been established for the site, as illustrated and color-coded green on the enclosed Site Geologic Map.

3. The subject site is located in Bishop Basin, a fault-bound, down-dropped block typical of the basins found in the Basin and Range Province. The fault that bounds the basin's east side is the White Mountain frontal fault system.
4. The White Mountain frontal fault has been zoned by the State of California according to the Alquist-Priolo Earthquake Fault Zone Act (Davis, 1985), and the site lies entirely within this zone.
5. Five significant active faults and countless subsidiary shears and cracks are known to exist and have been mapped within the limits of the subject site.
6. Evidence of primary surface rupture on the subject site was observed, mapped and published following the July 21, 1986 Chalfant Valley earthquake sequence, and they correspond to Significant Fault Nos. 4 and 5.
7. Review of aerial photographs indicated evidence of active faulting across the subject site.
8. Evidence for active faulting was observed during the site reconnaissance and during the subsurface fault investigation.
9. According to the 1997 UBC, the White Mountain frontal fault is approximately 105 km in total length, has a slip rate of 1.0 mm/yr, has an $M_{MAX}$ =7.1, and a recurrence interval of approximately 1,224 years.
10. A deterministic seismic analysis performed for the subject site indicates that the peak horizontal ground acceleration estimated for a maximum earthquake event within the specified radius is 0.49g.
11. Vertical ground accelerations are estimated to be approximately 2/3 of the horizontal acceleration for faults in the Basin and Range Province.
12. The largest estimated site acceleration based historical earthquake data was 0.28g, which occurred during the July 21, 1986 Chalfant Valley earthquake sequence.
13. Based on the results of the probabilistic analysis, the estimated ground acceleration during an Upper-Bound Earthquake and a Design Basis Earthquake for the site are 0.45g and 0.34g, respectively.
14. No known absolute-age data for the alluvial sediments were available at the time this report was prepared; however, the youngest fault-related soil deposits on the subject site are likely less than or equal to Recent age (≤11,000 years old).
15. The subject site, Chalfant Valley and the eastern California region are subject to naturally occurring earthquakes; however, it should be noted that the time, location or magnitude of such an event cannot be accurately predicted at this time.
16. Geologic inspections should be made by SGSI during future grading and development in order to confirm the findings contained in this report.
17. If loose trench backfill material is encountered during future foundation construction, the loose material should be removed and compacted.

## 7.0. LIMITATIONS

This report has been prepared for the sole use and benefit of our client. The conclusions of this report pertain only to the site investigated. The intent of the report is to advise our client of the geologic and geotechnical recommendations relative to the future development of the proposed project. It should be understood that the consulting provided and the contents of this report are not perfect. Any errors or omissions noted by any party reviewing this report, and/or any other geotechnical aspects of the project, should be reported to this office in a timely fashion. The client is the only party intended by this office to directly receive this advice. Unauthorized use of or reliance on this report constitutes an agreement to defend and indemnify Sierra Geotechnical Services Incorporated from and against any liability, which may arise as a result of such use or reliance, regardless of any fault, negligence, or strict liability of Sierra Geotechnical Services Incorporated.

Conclusions and recommendations presented herein are based upon the evaluation of technical information gathered, experience, and professional judgment. Other consultants could arrive at different conclusions and recommendations. Final decisions on matters presented are the responsibility of the client and/or the governing agencies. No warranties in any respect are made as to the performance of the project.

The findings of this report are valid as of the present date. However, changes in the conditions of a property can occur with the passage of time, whether they are due to natural processes or the works of man on this or adjacent properties. In addition, changes in applicable or appropriate standards may occur, whether they result from legislation or the broadening of knowledge. Accordingly, the findings within this report may be invalidated wholly or partially by changes outside our control. Therefore, this report is subject to review and should not be relied upon after a period of three years.

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## APPENDIX A

FIGURES:

FIGURE 1 Site Location Map
FIGURE 2 Regional APEFZ Map (from Davis, 1985)
FIGURE 3 Regional Geologic Map (from Bateman, 1966; Crowder and Sheridan, 1972)
FIGURE 4 Site Soil Stratigraphy Map (modified from Schell, 2001)

## APPENDIX B

PLATES:

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| PLATE 1 | Site Geologic Map |
| PLATE 2 | Geologic Cross Sections A-A' and A'-A" |
| PLATE 3 | Site Aerial Photograph – 1944 |
| PLATE 4 | Site Aerial Photograph – 1944 |
| PLATE 5 | Site Aerial Photograph – 1951 |
| PLATE 6 | Site Aerial Photograph – 1973 |
| PLATE 7 | Site Aerial Photograph – 1973 |
| PLATE 8 | Site Aerial Photograph – 1990 |
| PLATE 9 | Site Aerial Photograph – 1990 |

## APPENDIX C

LOG OF WATER PRODUCTION WELL

(prepared by GS Environmental dated July 14, 2004)

## APPENDIX D

SEISMICITY ANALYSES:

EQFAULT Results – Deterministic estimation of peak acceleration from digitized faults
EQSEARCH Results – Estimation of peak acceleration from California earthquake catalogs
FRISKSP Results – Probabilistic earthquake hazard analyses
UBCSEIS Results – Computation of 1997 UBC seismic design parameters

## APPENDIX E

TRENCH LOGS:

Geologic Log of Trench T-1 – Sheets 1 thru 11
Geologic Log of Trench T-2 – Sheets 1 thru 9
Geologic Log of Trench T-3 – Sheets 1 thru 5
Geologic Log of Trench T-4 – Sheets 1 thru 6
Geologic Log of Trench T-5 – Sheets 1 thru 12
Geologic Log of Trench T-6 – Sheets 1 thru 12
Geologic Log of Trench T-7 – Sheets 1 thru 13
Geologic Log of Trench T-8 – Sheets 1 thru 6
Geologic Log of Trench T-9 – Sheets 1 thru 7